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STATIC STABILIZERS FOR BRIDGES

FIELD OF THE INVENTION

[0001] The present invention relates generally to bridges, and more particularly, the present invention relates to apparatus for reducing impact loads to movable bascule bridge leafs and associated support structures as the leafs close as well as for maintaining static stability of the leafs when fully closed.

BACKGROUND OF THE INVENTIION

[0002] Bascule bridges need to possess the ability for the bridge operator to quickly and reliably change span orientation to alternately permit the passage of land and waterway traffic. Bascule bridges must be able to open and close on demand; yet, at the same time they should be as rigid in their closed position as a fixed span. The system intended to secure bridge leafs in the closed position is customarily known as a "Static Stabilizing System" and it normally includes components such as span locks, live load shoes, anchorages, machinery brakes and, in some instances, tail locks. Live load shoes and anchorages are the heart of the system because they transfer the traffic loads directly from the leaf to the pier. Both of these components are frequently subjected to shock loads both when the leaf is closing into its fully seated position and when the leaf is closed with heavy traffic crossing the span. Leaf pounding, or bounce, resulting from vehicle passage and from the leaf slamming down hard onto its seats with each closing, imparts shock loads to the movable leaf structure as well as

to the pier and supporting structures. Repetitive shock loading causes abnormal wear of the live load shoes, anchorages and their respective seats.

[0003] Over years of bridge service, the excessive wear, coupled with normal thermal expansion and contraction, corrosion and deterioration, diminishes the ability of the components to act in concert with one another and function as a system. Many serious problems result, including distress and failures in machinery components, which are directly attributable to poorly adjusted and maintained static stabilizing components. For example, there is spalling and cracking of live load seat concrete support columns from frequent high shock loads due to slamming the leaf onto its seat during closing plus repetitive shock loads from vehicles passing across the span; fracture of pinion or rack teeth in the operating machinery caused by cyclic shock loads on both faces of a tooth while the leaf is closed; and, fracture of trunnion bearing bushings caused by extremely high loads and repetitive shocks due to poorly adjusted live load shoes, anchorages and span locks.

[0004] Frequent periodic bridge maintenance is required to assure that live load shoes are in firm contact with their seats and the anchorages are adjusted as intended. Adjustment usually requires complete removal of each live load shoe and anchorage in order to insert shims of proper thickness between them and their respective supporting structures. When the leaf is closed and the span locks are engaged, the live load shoes should not have any clearance with their seats. Correct anchorage adjustments depend on the particular design of the bascule leaf. Some do not require any clearance with their seats, and others require a slight, e.g. 0.020 to 0.050 inch clearance. Live load shoe and anchorage adjustment is tedious and difficult because the components are cumbersome, weighing hundreds of pounds, and because anchorages are often situated in inaccessible locations with respect to the

bascule leaf. Adjustment is a time-consuming, labor-intensive process that requires the span be closed to all vehicular and waterway traffic, and this results in inconveniences to the traveling public. Failure to keep the static stabilizing system properly adjusted is an invitation to more serious trouble and damage, greater repair and replacement costs, and lengthier periods of inconvenience to users of the bascule bridge.

OBJECTS OF THE INVENTION

[0005] Accordingly, it is an object of the present invention to provide an improved bascule bridge static stabilizing system which minimizes the shock loads caused by slamming down of the leaf during closing and resulting from the passage of heavy vehicular traffic when the leaf is fully closed.

[0006] Another object is to provide apparatus useful with a bascule bridge leaf to assure positive stability and integrity for the leaf in the closed position.

[0007] Yet another object is to provide a bascule bridge static stabilization system in which the bascule leaf can be maintained and repaired with a minimum of interruption of bridge service to vehicular and waterway traffic and attendant inconvenience to the traveling public.

[0008] Still another object is to provide a bascule bridge leaf static stabilizing system which can be easily adjusted for correct clearance between contacting parts to ensure positive integrity and rigidity throughout the bridge leafs when in their closed position.

[0009] A further object of the invention is to provide a unique energy-absorbing assembly for use with a bascule bridge leaf to enable it to be readily adjusted *in situ* for

proper contact between support members and the leaf without causing major disruption of bridge service to vehicular and waterway traffic.

[0010] A still further object is to provide for a bridge span, a live load energy-absorber which is easy to install or to remove for replacement or repair, and which can be manufactured and maintained efficiently.

SUMMARY OF THE INVENTION

[0011] These and other objects, features and advantages of the invention are accomplished by means of energy-absorbing static stabilizers juxtaposed with a bridge span and its associated supporting structure to cushion shock loading. Each stabilizer includes a stack of Bellville washer springs carried within a housing juxtaposed between a fixed structure and an end portion of the span. The spring stack is preferable vertically adjustable in the housing to enable a span leaf-engageable bearing cap to be adjusted *in situ* to effect proper clearance when used in association with bascule bridges. An embodiment that does not include the adjustability feature is also disclosed for use with fixed span bridges.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For a more complete understanding and appreciation of the invention and its many attendant advantages, reference will be made to the following detailed description taken in conjunction with the accompanying drawings, in which:

[0013] FIGS.1A, 1B and 1C are schematic representations in elevation of three bascule bride embodiments according to the invention;

[0014] FIG. 2 is a plan view of an adjustable energy absorbing stabilizer assembly for use in effecting static stabilization of the bascule bridge embodiments of FIGS.1A, 1B and 1C;

[0015] FIG. 3 is a view in cross section of the assembly of FIG. 2 taken in a radial plane on Line 3-3 of FIG. 2;

[0016] FIG. 4 is a view of a portion of the assembly of FIG.2 taken in a transverse plane on Line 4-4 of FIG.3; and

[0017] FIG. 5 is a view in cross section of the portion of the assembly of FIG. 2 taken in a plane on Line 5-5 of FIG. 4.

[0018] FIG. 6 is a view in vertical cross- section of another embodiment which does not include *in situ* adjustability features.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] Referring now to the drawings, wherein like reference numerals and characters denote like or corresponding parts throughout the several views, FIG. 1A illustrates one embodiment of the invention incorporated in a trunnion bascule bridge 10 having a pair of opposed complementary span sections or leafs 10a and 10b. Each leaf, such as the leaf 10a, pivots about a trunnion16 supported in a bearing (not shown) mounted on a fixed pier (not shown). The leafs 10a and 10b are similar in construction and include at least two girders 12 extending the full length of the movable span. Each girder has a forward leaf span portion 12a and a reward leaf tail portion 12b. A road bed surface 15 for vehicular traffic is supported by the leaf girders 12 on its forward span extension over a waterway below the bridge. A counterweight 17 is attached to rearward leaf tail portions 12b of girders

12 so that the movable leaf 10a is essentially balanced about a horizontal pivot axis extending through the trunnion16. A motor driven pinion 18 meshes with a sector gear 20 affixed to girders 12 for rotating the leaf 10a from a substantially horizontal, or closed position endwise aligned with companion leaf 10b and spanning between opposed approach roadways 22 (shown in full) to an open upwardly-inclined position (shown in phantom). In this embodiment, a road break 24 is located forwardly of the trunnion 16 toward an outer end 12a of girder 12. Preferably, an energy absorbing span lock system 18, such as disclosed in U.S. Patent 6,588,041, issued to Steward Machine Co., Inc. the owner of the present application, connects to outer ends of leafs 10a and 10b when they are aligned with in the bridge in its fully closed position.

[0020] According to this preferred embodiment, two energy-absorbing static stabizer assemblies 28 and 29, are provided in juxtaposition with respect to the leaf trunnion 16 to statically secure bridge leaf 10a when closed and to absorb shocks while closing. One assembly 28, commonly called a live load shoe, is mounted on a top surface of a fixed concrete pier 30 located below the bridge leaf 10 for releasable contact with a lower surface of girder 12 between trunnion 16 and the forward outer end 12a of girder 12. The other assembly 29, commonly called an anchorage, is mounted underneath approach roadway structure 22 for releasable contact with an upper surface of the rearward tail end portion of the girder 12b in the vicinity of the counterweight 17.

[0021] The energy absorbing assemblies 28 and 29 are adjusted with the leafs10a and 10b in their closed positions in relation to one another for cooperatively reducing repetitive, high shock loads to the supporting structures 30 and 22 resulting from constant, heavy vehicular traffic. To this end, as best seen in FIGS. 2-5, each energy absorbing assembly,

such as assembly 28, is of like construction to the other, but each may differ in size and resiliency according to design shock loads expected to be encountered. Each assembly, such as the assembly 28, comprises a housing 32 having a cylindrical wall 34 closed at one end by a planar rectangular base 36 that is normal to a central vertical cylindrical axis A-A. The base 36 is adapted to be mounted by conventional means, such as lag bolts, (not shown) on either pier 30 or under approach roadway structure 22. The housing 32 is enclosed at the end opposite the base 36 by a rectangular cap shoe 38 having a circular flange 40 depending into cylindrical wall 34 on vertical axis A-A. A protective skirt 41depends from the cap periphery to encircle an annular gap 43 between the telescopically overlapping surfaces of housing wall 34 and cap shoe 38 for preventing foreign matter from entering the assembly 28. An arcuate load bearing surface 38a is provided on the cap to engage girders 12 along a single line of contact L-L as well known in the art.

[0022] The cap shoe 38 is adjustable relative to the base 36. To this end, a cup-shaped spring carriage 48 is mounted inside the cylindrical housing wall 34 for vertical adjustment relative thereto. The inner surface of spring carrier 48 is contiguous with a bushing 46, and the outer surface has threads 48b which threadedly engage threads 34b on the inner surface of the housing cylindrical wall 34. The threads 34b extend upwardly from an annular bottom shoulder 36a in base 36. A cylindrical guide pin 42 is welded at W around its upper end to the underside of cap shoe 38. The guide pin depends into carrier 47 through a stack of Bellville spring washers 44 coaxially confined between two spaced apart flat washers 45, a shoulder 48a of the annular spring carrier 48, and a guide bushing 46. The lower end portion of guide pin 42 depends into a recess 36b circumscribed by shoulder 36a for mounting a washer 50 and a retainer ring 52 in an annular groove 42a to secure Bellville

spring washers 44 axially between the cap shoe 38 and the adjustable spring carrier 48. As best seen in FIG. 4, guide pin 42 terminates in a diametrical slot 54 for receiving with an axial clearance a diametrical elongate yoke 56 which is connected at opposite ends to carrier 48 by bolts 58 to assure correct orientation of arcuate surface 38a with aligning slots 64 in spring carrier 48.

[0023] The stabilizer assembly 28 is lubricated prior to being placed in service, and can be lubricated while in service. For this purpose, at least one grease cap 38 (Fig. 3) is mounted on housing wall 34 for communicating via one or more passages 31a through spring carrier 48 to enable additional heavy duty lubricants to be pumped into the housing periodically. A plurality of grease cups 31 and related passages may be provided at various locations in the periphery of the housing wall 34 to afford handy access for lubrication after installation. Any excess lubricant can overflow through the gap 43 between the cap shoe and housing wall.

[0024] The stabilizer assemblies are adjusted *in situ* while bridge leafs 10a and 10b are in the closed position with no vehicular traffic passing across the leafs. To this end, sockets 60 are provided in opposite sides of each shoe 38 approximately aligned with the line of contact L-L. An elongate bar (not shown) is inserted into a sockets for rotating the cap shoe 38 and spring carrier 48 in housing 34 until a desired clearance, as required by the particular application, is obtained with the leaf girder 12. As the cap shoe 38 rotates, threads 34b and 48b slowly displace the spring carrier 48 relative to housing 32. The spring carrier 48 is locked in selected 180° rotational increments by means of at least one, but preferably a pair of, alignment screws 62 threaded into housing wall 34 and laterally engageable in diametrically opposed vertical slots 64 in carrier 48. Each 180° increment of rotation of shoe

38 displaces spring carrier 48 upwardly or downwardly an amount equal to one half of the thread pitch. A preferred thread pitch is fourteen (14) threads per inch. With no external loads present on cap shoe 38, the Bellville washers are in a relaxed condition, but under either vehicular traffic loading, or slamming of the leafs upon closing, the Bellville spring washers 44 compress to absorb the shock loads.

[0025] By way of example, and not by way of limitation, one version of a static stabilizer designed to accommodate a maximum vertical load of about 132,000 pounds has an overall volumetric dimension of about one cubic foot. The maximum vertical travel of the cap shoe is limited to less than about .100 inch. For a maximum live load of 132,000 pounds, five Bellville springs are used in series each carrying a maximum live load component of about 26,400 pounds. Thus, the overall spring rate is in excess of about 1,000,000 pounds/inch of deflection. The pitch of the spring carrier threads is such as to provide a total height adjustment on the order of about ½ inch in about 1/32 inch increments for each 180° turn for each of the cap shoe about its vertical axis. In the event that a lower live load is anticipated, one or more spring washers could be replaced with one or more flat washers of the same thickness. As a result, the stabilizer design is able to be readily configured for a variety of design loads with minimal changes in either external or internal structure. This facilitates efficient manufacture and assembly. In addition, the static stabilizers can be mounted cap side up as illustrated at 28 in Fig. 1A or cap side down as illustrated at 29. Preferably, the static stabilizers are mounted to stationary bridge structures as illustrated, but there may be applications in which mounting on moveable bridge components might be indicated.

[0026] FIG. 1B illustrates another embodiment of a trunnion bascule bridge 70 having opposed leaf span girders 72 of like construction shown in solid lines locked in a fully closed position. Each leaf supports a road bed 73 spanning opposite approach roadway structures, such as roadway 74. A span lock system 18, as described *supra,* is shown in phantom connecting the leaf spans when in their fully closed positions. Each leaf span girder 72 includes a trunnion 76, carried in a support bearing mounted on a fixed pier (not shown). Each leaf girder 72 is pivoted from a closed position to an open position by a motor driven pinion 78 meshing with a sector gear 80 fixed to each girder 72. A road break 82 is provided between roadbed 73 and approach roadway structure 74 along the width of leaf girders 72 between trunnion 76 and the rearward leaf tail portion 72a extension of girder 72.

[0027] In this embodiment, two energy absorbing assemblies, such as assembly 28, described above, are installed at predetermined locations along the length of leaf girder 72 at locations similar to those described in FIG. 1. One assembly 28, a live load shoe, is mounted by its base 36 on a fixed concrete support 84 and contacts a lower surface of leaf 72; the second assembly 29, an anchorage, is mounted by its base 36 to a lower surface of the support structure for approach roadway 74 to engage an upper surface of leaf tail end portion 72a; and a third assembly 28', another live load shoe, is mounted by its base 36 on a fixed concrete support 86 for engaging a lower surface of a retractable tail lock 88 of conventional construction. Each cushion shoe assembly 28 and 29 is adjusted as described above, and as required by the design, with the span in the closed position and the tail lock 88 disposed in its full line position in FIG. 1B to statically stabilize the span against shock loads as described above.

[0028] In a further embodiment illustrated in FIG. 1C, a rolling lift bascule bridge 90 having opposed leafs of similar construction is shown in solid lines in a fully closed position supporting a road bed 94 and is shown in phantom lines in the open position. The leafs are locked in the closed position by a span lock system 18, discussed, *supra*, with road breaks 97 located between road bed 94 and approach roadway structure 96. The tail end 92a of each girder 92 has an arcuate sector 98 of constant radius measured from a horizontal axis of rotation A near an inner, or tail, end 92a thereof. A motor-driven pinion 100 fixed to leaf 92 at axis A causes sector 98 to roll on an elongate horizontal bearing plate 102 mounted on a concrete pier 106.

[0029] One energy-absorber cushion shoe assembly 29, as described above, is disposed between a tail end portion 92a of each girder 92 and a static structure adjacent the roadway approach to provide a desired tail-end static stabilization of the bridge leaf. To this end, assembly 29, an anchorage, is mounted below a fixed structure 108 above leaf tail end portion 92a for engaging an upper surface portion 92b thereof. As described above, the assembly 29 is adjusted *in situ* to insure firm contact of its cap shoe with girder tail end portion 92a.

[0030] In the preceding embodiments, adjustable static stabilizers are disclosed for use in association with various types of bascule bridges that require periodic adjustment due to the inherent nature of their moveable components. For fixed span bridges that may not require periodic adjustment, but which are subject to shock loading due to heavy-fast moving traffic, another embodiment is provided. As best seen in FIG. 6, the static stabilizer 128 illustrated is similar in many respects to the static stabilizer 28 in that it has a similar moveable cap shoe 138, a somewhat similar housing 136, and a stack of Bellville spring

washers 144. In this embodiment however, the spring washer stack 144 is not vertically adjustable in the housing 136. Rather, the stack is are confined in a cylindrical chamber 136a between a housing bottom wall 136b and the underside of the shoe cap boss 142. The shoe cap 138 is connected to the housing 136 in a manner similar to the stabilizer 28, having a connecting rod portion 142a depending from the shoe cap boss and fastened in a similar manner at its lower end to a circular 136c flange adjacent to the base of the housing 136. A closure plate 156 is slotted (not shown) for cooperating with a tang (not shown) on the bottom of the connecting rod portion 142a to anti-rotatively connect the shoe cap to the housing 136. An O-ring 142 cooperates with a descending peripheral skirt 141 to protect the interior of the stabilizer from the ingress of foreign matter. Downward displacement of the shoe cap 138 compresses the spring washers in the stack 144 to absorb shock loads such as in the manner described heretofore. In this embodiment, the displacement is less than about .100 inches as indicated by the dimension d in FIG.6. By way of example and not by way of limitation, in this embodiment, for a dead load design of 100,000 lbs., and a 212,000 lbs. load to full deflection "d", eight (8) Bellville spring washers are contained in a housing having an overall height of about 16 inches and a base 24 inches square.

[0031] In view of the foregoing, it should be apparent that the disclosed embodiments provide statically stabilized bridges in which shock loads are reduced. As a result, damage to the piers and supporting structures, and consequent costly repairs and replacements are greatly reduced. In addition, when used on bascule bridges the static stabilizing systems are easy to adjust with a minimum of bridge downtime and cost and a minimum of interruption of service to both vehicular and waterway traffic.

[0032] Various modifications, alterations and changes may be made without departing from the spirit and scope of the invention as defined in the appended claims.